PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 21 October 1999 (21.10.99)	
International application No. PCT/US98/03811	**Applicant's or agent's file reference** F8172-8059
International filing date (day/month/year) 20 March 1998 (20.03.98)	**Priority date** (day/month/year)
Applicant ATSUMI, Eiji et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

10 September 1999 (10.09.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer A. Karkachi
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

WO 99/49413
PCT/US98/03811

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
GOLDHUSH, Douglas, H.
Nikaido, Marmelstein, Murray and Oram LLP
Suite 330
Metropolitan Square - "G" Street Lobby
655 15th Street, N.W.
Washington, DC 20005-5701
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 30 September 1999 (30.09.99)	
Applicant's or agent's file reference F8172-8059	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/US98/03811	20 March 1998 (20.03.98)	

Applicant
MITSUBISHI ELECTRIC CORP. et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,CN,EP,IL,JP,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GE,GH,GM,GW,HU,ID,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   30 September 1999 (30.09.99) under No. WO 99/49413

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

GOLDHUSH, Douglas, H.
Nikaido, Marmelstein, Murray and Oram LLP
Suite 330
Metropolitan Square - "G" Street Lobby
655 15th Street, N.W.
Washington, DC 20005-5701
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 21 October 1999 (21.10.99)	
Applicant's or agent's file reference F8172-8059	**IMPORTANT INFORMATION**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/US98/03811	20 March 1998 (20.03.98)	

Applicant
MITSUBISHI ELECTRIC CORP. et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,SD,SZ,UG,ZW
   EP :AT,BE,CH,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,BR,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,ML,MR,NE,SN,TD,TG
   National :AL,AM,AT,AZ,BA,BB,BY,CH,CU,DK,EE,ES,FI,GB,GE,GH,GM,GW,HU,ID,IS,
   KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MW,MX,PT,SD,SG,SI,SL,TJ,TM,TR,TT,
   UA,UG,UZ,VN,YU,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing, if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

A. Karkachi

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

GOLDHUSH, Douglas, H.
Nikaido, Marmelstein, Murray and Oram LLP
Suite 330
Metropolitan Square - "G" Street Lobby
655 15th Street, N.W.
Washington, DC 20005-5701
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 15 September 1999 (15.09.99)	
Applicant's or agent's file reference F8172-8059	**IMPORTANT NOTIFICATION**
International application No. PCT/US98/03811	**International filing date** (day/month/year) 20 March 1998 (20.03.98)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
MITSUBISHI ELECTRIC CORP. 5-1-1, Ofuna Kamakura Kanagawa 247 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
MITSUBISHI ELECTRIC CORP. 2-3, Marunouchi 2-chome Chiyoda-ku, Tokyo 100-8310 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Jocelyne Rey-Millet

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

GOLDHUSH, Douglas, H.
Nikaido, Marmelstein, Murray and Oram LLP
Suite 330
Metropolitan Square - "G" Street Lobby
655 15th Street, N.W.
Washington, DC 20005-5701
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year)
15 September 1999 (15.09.99)

Applicant's or agent's file reference
F8172-8059

IMPORTANT NOTIFICATION

International application No.
PCT/US98/03811

International filing date (day/month/year)
20 March 1998 (20.03.98)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address
ATSUMI, Eiji
9317 Sudbury Road
Silver Spring, MD 20901
United States of America

State of Nationality: JP
State of Residence: US
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [X] the residence

Name and Address
ATSUMI, Eiji
c/o Mitsubishi Electric Corp.
Information Technology R & D Center
5-1-1 Ofuna Kamakura-shi, 247-8501
Japan

State of Nationality: JP
State of Residence: JP
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Jocelyne Rey-Millet
Telephone No.: (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/US 98/03811
International Application No.

20 MAR 1998 (20.03.98)
International Filing Date

PCT INTERNATIONAL APPLICATION RO/US
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* F8172-8059

Box No. I TITLE OF INVENTION
LOSSY/LOSSLESS REGION-OF-INTEREST IMAGE CODING

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*
University of Maryland
Office of Technology Liaison
4312 Knox Road
College Park, MD 20742
US

☐ This person is also inventor.

Telephone No.
301-405-4209

Facsimile No.
301-314-9871

Teleprinter No.

State *(i.e. country)* of nationality:
US

State *(i.e. country)* of residence:
US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*
Mitsubishi Electric Corp.
5-1-1 Ofuna Kamakura
Kanagawa 247, Japan

This person is:
☒ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:
JP

State *(i.e. country)* of residence:
JP

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
GOLDHUSH, Douglas H.
Nikaido, Marmelstein, Murray and Oram LLP
655 15th Street N.W. Suite 330
Metropolitan Squre - "G" Street Lobby
Washington, DC 20005-5701
▲US

Telephone No.
202-638-5000

Facsimile No.
202-638-4810

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

▲ RO/US

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*
ATSUMI, Eiji
9317 Sudbury Road
Silver Spring, MD 20901
US

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: JP

State *(i.e. country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*
FARVARDIN, Nariman
10312 Nolan Drive
Rockville, MD 20850
US

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: US

State *(i.e. country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

This person is:
☐ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

This person is:
☐ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☒ AL Albania .....
☒ AM Armenia .....
☒ AT Austria .....
☒ AU Australia .....
☒ AZ Azerbaijan
☒ BA Bosnia and Herzegovina .....
☒ BB Barbados
☒ BG Bulgaria .....
☒ BR Brazil .....
☒ BY Belarus
☒ CA Canada
☒ CH and LI Switzerland and Liechtenstein
☒ CN China .....
☒ CU Cuba .....
☒ CZ Czech Republic .....
☒ DE Germany .....
☒ DK Denmark .....
☒ EE Estonia .....
☒ ES Spain .....
☒ FI Finland .....
☒ GB United Kingdom
☒ GE Georgia .....
☒ GH Ghana .....
☒ GM Gambia
☒ GW Guinea-Bissau .....
☒ HU Hungary .....
☒ ID Indonesia
☒ IL Israel .....
☒ IS Iceland
☒ JP Japan .....
☒ KE Kenya .....
☒ KG Kyrgyzstan .....
☒ KP Democratic People's Republic of Korea .....
☒ KR Republic of Korea .....
☒ KZ Kazakhstan .....
☒ LC Saint Lucia
☒ LK Sri Lanka
☒ LR Liberia
☒ LS Lesotho .....
☒ LT Lithuania
☒ LU Luxembourg
☒ LV Latvia
☒ MD Republic of Moldova .....
☒ MG Madagascar .....
☒ MK The former Yugoslav Republic of Macedonia .....
☒ MN Mongolia
☒ MW Malawi .....
☒ MX Mexico .....
☒ NO Norway
☒ NZ New Zealand .....
☒ PL Poland .....
☒ PT Portugal .....
☒ RO Romania
☒ RU Russian Federation .....
☒ SD Sudan
☒ SE Sweden
☒ SG Singapore
☒ SI Slovenia .....
☒ SK Slovakia .....
☒ SL Sierra Leone
☒ TJ Tajikistan .....
☒ TM Turkmenistan .....
☒ TR Turkey .....
☒ TT Trinidad and Tobago .....
☒ UA Ukraine .....
☒ UG Uganda .....
☒ US United States of America .....
☒ UZ Uzbekistan .....
☒ VN Viet Nam .....
☒ YU Yugoslavia .....
☒ ZW Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☒ CY Cyprus .....
☐ .....
☐ .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

CANCELED EXOFFICIO BY RO/US

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1)	( )		
item (2)	( )		
item (3)	( )		

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☐ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): _____

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA/ US

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office): Date *(day/month/year):* Number:

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	:	4 sheets
2. description	:	16 sheets
3. claims	:	8 sheets
4. abstract	:	1 sheets
5. drawings	:	11 sheets
Total	:	40 sheets

This international application is accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☐ other *(specify):*

Figure No. 11 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

x _____

Douglas H. Goldhush
Agent of Record
[Reg. No. 33,125]

▲ DELETED BY RO/US

For receiving Office use only (20.03.98)

1. Date of actual receipt of the purported international application: 79 Rec'd PCT/PTO 20 MAR 1998
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority specified by the applicant: ISA/US
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: DOUGLAS H. GOLDHUSH
NIKAIDO, MARMELSTEIN, MURRAY & ORMA LLP
655 15TH STREET, N.W.
SUITE 330
METROPOLITAN SQUARE - "G" STREET LOBBY
WASHINGTON, DC 20005-5701

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of Mailing *(day/month/year)* 29 NOV 1999	
Applicant's or agent's file reference F8172-8059	REPLY DUE within TWO months from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US98/03811	20 MARCH 1998	NONE

International Patent Classification (IPC) or both national classification and IPC
IPC(6): G06K 9/36 and US Cl.: 382/240

Applicant
UNIVERSITY OF MARYLAND

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I [X] Basis of the opinion
- II [ ] Priority
- III [ ] Non-establishment of opinion with regard to novelty, inventive step or industrial applicability
- IV [ ] Lack of unity of invention
- V [X] Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI [ ] Certain documents cited
- VII [ ] Certain defects in the international application
- VIII [ ] Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. ~~The applicant may, before the expiration of that time limit, request this Authority to grant an extension., see Rule 66.2(d).~~

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 *bis*.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 20 JULY 2000

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	BIJAN TADAYON Jeri Hill
Facsimile No. (703) 305-3230	Telephone No. (703) 308-7595

Form PCT/IPEA/408 (cover sheet) (January 1994)*

WRITTEN OPINION

International application No.
PCT/US98/03811

I. Basis of the opinion

1. This opinion has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".)*:

[X] the international application as originally filed.

[X] the description, pages 1-16 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.

[X] the claims, Nos. 1-20 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1-7 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE

[X] the claims, Nos. NONE

[X] the drawings, sheets/~~fig~~ NONE

3. [ ] This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:
NONE

WRITTEN OPINION

International application No.
PCT/US98/03811

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	NONE	YES
	Claims	1-20	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-20	NO
Industrial Applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

1. Claims 1-20 lack novelty under PCT Article 33(2) as being anticipated by Shapiro (US patent number 5412741).

Shapiro teaches the features of the claims 1-20 regarding compression, sorting, and prioritizing the data (see from col. 2 line 41 to col. 3 line 19).

2. Claims 1-20 meet the criteria set out in PCT Article 33(4), because it is useful for compression, sorting, and prioritizing the data.

---------- NEW CITATIONS ----------
NONE

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

TIME LIMIT:

The time limit set for response to a Written Opinion may not be extended. 37 CFR 1.484(d). Any response received after the expiration of the time limit set in the Written Opinion will not be considered in preparing the International Preliminary Examination Report.

09/623464
422 Rec'd PCT/PTO 12 SEP 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

Hand Carry to PCT
Attn: IPEA/US

In re the application of: University of Maryland, et al.

International Application Number: PCT/US98/03811

Filed: March 20, 1998

For: LOSSY/LOSSLESS REGION-OF-INTEREST IMAGE CODING

REPLY TO WRITTEN OPINION

Commissioner of Patents and Trademarks
Box PCT
Washington, DC 20231

January 27, 2000

Sir:

Applicants acknowledge receipt of the PCT Written Opinion dated November 29, 1999, and respectfully submit the following comments as a response thereto.

Claims 1-20 were indicated as lacking novelty under PCT Article 33(2) as being anticipated by Shapiro (U.S. Patent No. 5,412,741). The Written Opinion took the position that Shapiro disclosed all of the elements of claims 1-20, regarding compression, sorting, and prioritizing the data. The Written Opinion also indicated that claims 1-20 met the criteria set out in PCT Article 33(4), as being useful for compression, sorting, and prioritizing the data.

Applicants respectfully submit that each of claims 1-20 should be found to be novel and to contain an inventive step as required by PCT practice.

Independent claim 1, upon which claims 2-4 are dependent, is directed to a method of image compression, with the method comprising the steps of providing digital image data in a computer-readable format, with the digital image data including data on values and coordinates for a plurality of pixels. A region of interest of an image is selected, said image being represented by the digital image data. The digital image data is sorted and prioritized according to at least two priority categories, with digital image data corresponding to the region of interest having a higher priority than digital

image data corresponding to areas outside of the region of interest. The sorted and prioritized digital image data is then transmitted to a remote location, with the digital information data corresponding to the region of interest being transmitted with higher priority than the areas outside of the region of interest.

Independent claim 5, upon which claims 17 and 18 are dependent, is directed to a method for encoding and decoding an image, with the method comprising the steps of providing digital image data in a computer-readable format, with the digital image data including data on values and coordinates for a plurality of pixels. The digital image data is sorted according to a mathematical sorting protocol. The digital image data is sorted and prioritized according to a predetermined prioritization formula. The sorted data is transmitted to a receiver, and the sorting and transmitting is repeated until a partial reconstructed image appears on a display at the receiver. A region of interest is then selected based upon the partial reconstructed image, and data is transmitted from the receiver to a computer transmitting data identifying the selected region of interest. The sorting of the digital image data is modified based upon the selected region of interest. Digital image data corresponding to the region of interest is sorted and prioritized to have a higher priority than digital image data corresponding to areas outside of the region of interest. The modified sorted and prioritized data is transmitted to the receiver, with the region of interest being transmitted with higher priority than the areas outside of the region of interest.

Independent claim 6, upon which claim 19 is dependent, is directed to a system for compressing a digital image, with the system comprising input means for inputting digital image data in computer-readable format with the digital image data including data on values and coordinates for a plurality of pixels for an image. A display means is connected to the input means for displaying the digital image data, and a selecting means is connected to the display means for selecting a region of interest of an image represented by the digital image data. Sorting and prioritizing means are connected to the selecting means for sorting and prioritizing the digital image data according to at least two priority categories. The digital image data corresponding to the region of interest has a higher priority than digital image data corresponding to areas outside of the region of interest. Transmitting means are provided for transmitting the sorted and prioritized data to a remote location. The transmitting means transmits the digital image

data corresponding to the region of interest with higher priority than the areas outside of the region of interest.

Independent claim 9 is directed to a system for encoding and decoding an image. Claim 9 includes input means, sorting means, transmitting means, receiving means, selecting means, and region of interest transmitting means, for transmitting data corresponding to a selected region of interest to the sorting means. The sorting means of claim 9 modifies the sorting of the digital image based upon data corresponding to the selected region of interest. Digital image data corresponding to the selected region of interest is sorted and prioritized by the sorting means to have a higher priority than digital image data corresponding to areas outside of the selected region of interest. The transmitting means transmits the modified sorted and prioritized data to the receiving means, with the selected region of interest being transmitted with a higher priority than areas outside of the region of interest.

Claims 10-13 are directed to computer programs embodied on a computer readable medium, with these computer programs being directed to region of interest prioritization. Claim 14 is directed to a method of image compression, and claim 16 is dependent thereupon.

As a result of the claimed configurations of the invention, an efficient image compression/decompression method and apparatus are provided wherein parts of an image can be compressed with a higher level of fidelity in the reproduced image than other parts of the image, based upon the region-of-interest selection. This results in faster and more efficient rendering of images using various types of computer equipment. It is respectfully submitted that Shapiro fails to disclose or suggest the present invention, and therefore fails to provide the critical and unobvious advantages discussed above.

Shapiro is directed to an apparatus and method for compressing information, utilizing zerotree coding of wavelet coefficients to dynamically generate a list of coefficient indices to be scanned. However, the use of wavelet coefficients as disclosed in Shapiro is for the purpose of improving the efficiency of the overall compression based upon an algorithm. The algorithm attempts to determine significance of particular coefficients, and estimate the significance of various coefficients for avoiding redundancy. The zerotree coding of Shapiro, therefore, is such that the coding order

is determined based upon the magnitude of the transformed coefficients of a wavelet transform image. This is significantly different from the present invention, wherein the coding order for transform coefficients is different within the selected region of interest than outside of the selected region of interest. By using the different criteria for the coding, the invention enables a user to select a region of interest which requires a higher quality or a higher resolution than other aspects of the image, and enable a more lossy yet faster compression algorithm to be used on the unselected regions of the image. Shapiro fails to disclose or suggest any configuration which enables a region of interest to be selected, and which therefore enables compression and decompression according to the systems, methods, and computer programs of the present claims.

In view of the fact that Shapiro fails to disclose or to suggest the elements of the independent claims, then Shapiro cannot be found to disclose or suggest the subject matter of any of the claims which are dependent thereupon.

In view of the above, applicants strongly but respectfully submit that the subject matter of each of claims 1-20 meets the criteria for novelty and inventive step under PCT practice. It is therefore respectfully requested that, upon reconsideration, a favorable examination report be issued in due course.

In the event that there are any fees due with respect to this paper, please charge Counsel's Deposit Account No. 01-2300.

Respectfully submitted,

ARENT FOX KINTNER PLOTKIN & KAHN PLLC

Douglas H. Goldhush
Attorney for applicants
Reg. No. 33,125

Atty. Docket No. F8172-8059

1050 Connecticut Avenue, N.W., Suite 600
Washington, D.C. 20036-5339
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DHG:scc:arw

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: DOUGLAS H. GOLDHUSH
NIKAIDO, MARMELSTEIN, MURRAY & ORMA LLP
655 15TH STREET, N.W.
SUITE 330
METROPOLITAN SQUARE - "G" STREET LOBBY
WASHINGTON, DC 20005-5701

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	05 APR 2000
Applicant's or agent's file reference F8172-8059	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US98/03811	20 MARCH 1998	NONE

Applicant
UNIVERSITY OF MARYLAND

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer BIJAN TADAYON Joni Hill
Facsimile No. (703) 305-3230	Telephone No. (703) 308-7595

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference F8172-8059	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US98/03811	International filing date *(day/month/year)* 20 MARCH 1998	Priority date *(day/month/year)* NONE
International Patent Classification (IPC) or national classification and IPC IPC(6): G06K 9/36 and US Cl.: 382/240		
Applicant UNIVERSITY OF MARYLAND		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand 10 SEPTEMBER 1999	Date of completion of this report 02 MARCH 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer BIJAN TADAYON Joni Hill Telephone No. (703) 308-7595

Form PCT/IPEA/409 (cover sheet) (January 1994)★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/03811

I. Basis of the report

1. This report has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation*

[X] the international application as originally filed.

[X] the description, pages 1-16 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.
pages _____ , filed with the letter of _____.

[X] the claims, Nos. 1-20 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.
Nos. _____ , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1-7 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.
sheets/~~fig~~ _____ , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE.

[X] the claims, Nos. NONE.

[X] the drawings, sheets/~~fig~~ NONE.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:

NONE

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/03811

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	NONE	YES
	Claims	1-20	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-20	NO
Industrial Applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

1. Claims 1-20 lack novelty under PCT Article 33(2) as being anticipated by Shapiro (US patent number 5412741).

Shapiro teaches the features of the claims 1-20 regarding compression, sorting, and prioritizing the data (see from col. 2 line 41 to col. 3 line 19).

2. Claims 1-20 meet the criteria set out in PCT Article 33(4), because it is useful for compression, sorting, and prioritizing the data.

3. Applicant argues that the reference does not teach the features of the claims, in particular, the steps of selecting a region of interest and sorting and prioritizing the digital image data. However, the examiner disagrees because the reference (Shapiro (US patent number 5412741)) teaches those features: selecting a region of interest (column 8 lines 1-17; figures 1-3) and sorting and prioritizing the digital image data (figure 3; figure 4; figures 9, 11; column 8 lines 1-17). Thus, the applicant's argument is not convincing.

---------- NEW CITATIONS ----------

NONE

E.K.

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06K 9/36

A1

(11) International Publication Number: **WO 99/49413**

(43) International Publication Date: 30 September 1999 (30.09.99)

(21) International Application Number: PCT/US98/03811

(22) International Filing Date: 20 March 1998 (20.03.98)

(71) Applicants *(for all designated States except US)*: MITSUBISHI ELECTRIC CORP. [JP/JP]; 2–3, Marunouchi 2–chome, Chiyoda–ku, Tokyo 100–8310 (JP). UNIVERSITY OF MARYLAND [US/US]; Office of Technology Liaison, 4312 Knox Road, College Park, MD 20742 (US).

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(74) Agent: GOLDHUSH, Douglas, H.; Nikaido, Marmelstein, Murray and Oram LLP, Suite 330, Metropolitan Square – "G" Street Lobby, 655 15th Street, N.W., Washington, DC 20005–5701 (US).

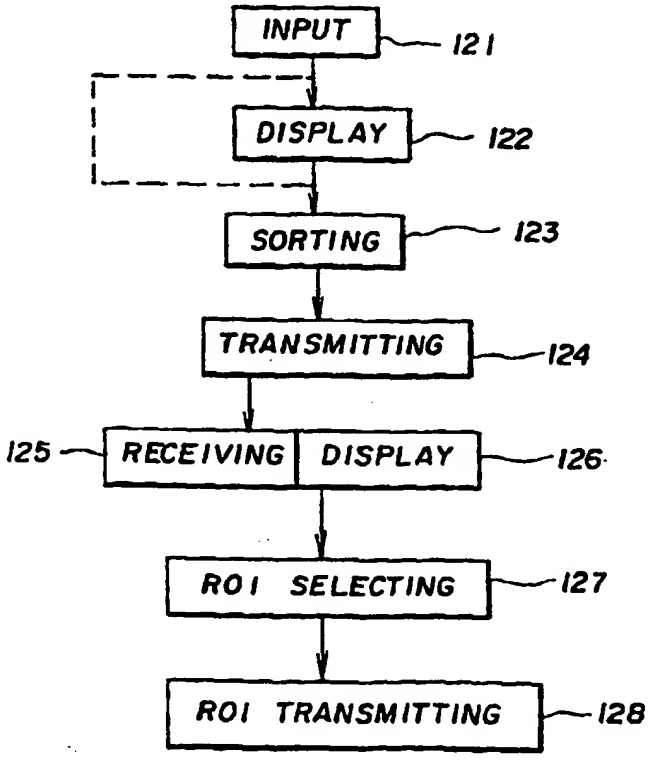
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: LOSSY/LOSSLESS REGION–OF–INTEREST IMAGE CODING

(57) Abstract

A method and apparatus for encoding digital image data wherein region of interest can be specified either before the encoding process has begun or during the encoding process (127), such that the priority of the encoder outputs are modified so as to place more emphasis on the region of interest, therefore increasing the speed and/or increasing the fidelity of the reconstructed region of interest. The system, therefore, enables more effective reconstruction of digital images over communication lines (128).



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TITLE OF THE INVENTION:

LOSSY/LOSSLESS REGION-OF-INTEREST IMAGE CODING

BACKGROUND OF THE INVENTION:

Field of the Invention:

Modern computers and modern computer networks enable the transfer of a significant amount of information between computers and between a computer and a storage device. When computers access local storage devices such as a local hard drive or local floppy drive, significant amounts of information can be quickly accessed. However, when seeking to access data from a remote storage location such as over a wide area network (WAN) or the internet, data transfer rates are significantly slower. Transferring large files, therefore, takes significant amounts of time. Additionally, storage of large files utilizes valuable and limited storage space. Photographic images and similar graphical images typically are considered to be large files, since an image conventionally requires information on each picture element or pixel in the image. Photographs and similar graphical images, therefore, typically require over one megabyte of storage space, and therefore require significant transmission times over slow network communications. In recent years, therefore, numerous protocols and standards have been developed for compressing photographic images to reduce the amount of storage space required to store photographic images, and to reduce transfer and rendering times. The compression methods essentially create mathematical or statistical approximations of the original image.

Compression methods can broadly be categorized into two separate categories: Lossy compression methods are methods wherein there is a certain amount of loss of fidelity of the image; in other words, close inspection of the reproduced image would show a loss of fidelity of the image. Lossless compression methods are ones where the original image is reproduced exactly after decoding. The present invention is directed to an efficient image compression method and apparatus wherein part of an image can be compressed with a higher level of fidelity in the reproduced image than other

parts of the image, based on a selection of a region-of-interest by the user who is initially encoding or compressing the image, or the user who receives and decodes the image data through interaction with the encoding side.

Description of the Related Art:

A currently popular standard for compressing images is called the JPEG or "J-peg" standard. This standard was developed by a committee called The Joint Photographic Experts Group, and is popularly used to compress still images for storage or network transmission. Recent papers by Said and Pearlman discuss new image coding and decoding methods based upon set partitioning in hierarchical trees (SPIHT). See Said and Pearlman, Image Codec Based on Set Partitioning in Hierarchical Trees, IEEE Transactions on Circuits and Systems for Video Technology, vol. 6, no. 3, June 1996, and Said and Pearlman, Image Multi-Resolution Representation, IEEE Transactions on Image Processing, vol. 5, no. 9, September 1996. The contents of these papers are hereby incorporated by reference. These references disclose computer software which, when loaded and running on a general purpose computer, performs a method and creates an apparatus which utilizes integer wavelet transforms which provide lossy compression by bit accuracy and lossless compression within a same embedded bit stream, or apparatus which utilizes non-integer wavelet transforms which provide lossy compression by bit accuracy within a single embedded bit stream. An image which is initially stored as a two dimensional array representing a plurality of individual pixels prioritizes bits according to a transform coefficient for progressive image transmission. The most important information is selected by determining significant or insignificant elements with respect to a given threshold utilizing subset partitioning. The progressive transmission scheme disclosed by Said and Pearlman selects the most important information to be transmitted first based upon the magnitude of each transform coefficient; if the transform is unitary, the larger the magnitude, the more information the coefficient conveys in the mean squared error (MSE, $D_{mse}()$) sense;

$$D_{mse}(p - \hat{p}) = \frac{\| p - \hat{p} \|^2}{N} = \frac{1}{N} \sum_i \sum_j (p_{i,j} - \hat{p}_{i,j})^2$$

where (i,j) is the pixel coordinate, with p, therefore representing a pixel value. Two dimensional array c is coded according to $c = \Omega(p)$, with $\Omega(\cdot)$ being used to represent a unitary hierarchical subband transformation. Said and Pearlman make the assumption that each pixel coordinate and value is represented according to a fixed-point binary format with a relatively small number of bits which enables the element to be treated as an integer for the purposes of coding. The reconstructed image $\hat{p}$ is performed by setting a reconstruction vector $\hat{c}$ to 0, and calculating the image as:

$$\hat{p} = \Omega^{-1}(\hat{c})$$

N is the number of image pixels, and the above calculation for mean squared-error distortion can therefore be made. Using mathematical assumptions, it is known that the mean squared-error distortion measure decreases by $\| c_{i,j} \|^2/N$. This fact enables pixel values to be ranked according to their binary representation, with the most significant bits (MSBs) being transmitted first, and also enables pixel coefficients with larger magnitude to be transmitted first because of a larger content of information. An algorithm is utilized by the encoder to send a value representing the maximum pixel value for a particular pixel coordinate, sorting pixel coordinates by wavelet transform coefficient values, then outputting a most significant bit of the various coefficients, using a number of sorting passes and refinement passes, to provide high quality reconstructed images utilizing a small fraction of the transmitted pixel coordinates. A user can set a desired rate or distortion by setting the number of bits to be spent in sorting passes and refinement passes. Utilizing a spatial orientation tree, as shown in Figure 1, pixel information is separated into a List of Insignificant Sets (LIS), a list of insignificant pixels (LIP), and a List of Significant Pixels (LSP). Figure 1 illustrates image 100, with a plurality of pixel sets 101, 102, ..., 10x therein. The spatial orientation tree is developed as known in the art, by decomposition of integer-valued or non-integer-valued wavelet transform

(WT) coefficients. Coefficients in the LH subband of each decomposition level forms the spatial orientation tree. In this example, parent node 101 has a series of roots and offspring nodes 102-107. The LIP is a list of coordinates of insignificant pixel or WT coefficients, the LIS is a list of coordinates of tree roots with insignificant descendent sets, with multiple types of entries on the list (Type A and Type B), and the LSP is a list of coordinates of significant pixels. Sorting and partitioning of the list contents is performed as illustrated in Figure 2. The significance determination which is made in the flow chart of Figure 2 is based upon a given significance threshold entries from the LIP which are determined to be significant at 202 LSP, 203, and entries which are determined not to be significant at 202 are returned to the LIP for testing during subsequent passes. If it is determined that all LIP entries have been tested at 204, then LIS entries begin to be tested. If all LIP entries are not tested, a next LIP entry is tested for significance at 202. Assuming all LIP entries are tested, LIS entries at 205 are tested at 206 to determine whether the LIS entries are type A, which are sets of coordinates of descendants of a node, or type B if the entry represents a difference between coordinates of descendants and offspring. If the sets are determined to be type A, significance is tested at 207. If significant, the set is partitioned at 208 into offspring and descendants of offspring with offspring being tested for significance at 209. If significant, the coordinate is placed on the LSP. If insignificant, the tested offspring is moved to the end of the LIP. If the initial type A entry is determined to be insignificant at 207, the entry is returned to the LIS. Type B LIS entries are tested for significance at 210, and moved to the LIP if significant or returned to the LIS if insignificant. After each test for significance, a one is output if the entry is determined to be significant, and a zero is output if the entry is determined to be insignificant. The ones and zeros are used to indicate when a specified number of bits have been output for termination purposes. Decoding occurs in a same, but reversed fashion. Entries of each list are identified by the pixel coordinates, with the LIP and LSP representing individual pixels, and the LIS representing sets of

coordinates, with the sets of coordinates being grouped according to their status as either coordinates of a descendent of a node of the spatial orientation tree.

Using the encoding algorithm mentioned above, sorting passes are performed until reaching the selected termination point, with an increase in sorting passes providing a decrease in distortion due to further refinement provided by more accurate significance classification. Increased sorting passes, however, requires additional time. The decoder duplicates the encoder's execution path in reverse to sort the significant coefficients, with "outputs" being changed to "inputs" for decoding, to recover appropriate ordering information. The coding method of the prior art, therefore, attempts to mathematically determine an area of the image which should have a higher fidelity or lower loss than areas of the image based upon the significance determinations. Figure 3 illustrates an important aspect of the SPIHT coding, which is repetitive sorting passes and refinement passes for a given threshold; sorting and refinement is repeated until encoding is complete. (Refer to the above-referenced articles for a more complete discussion of SPIHT coding).

SUMMARY OF THE INVENTION:

The present invention, however, is directed to an image encoding and decoding method and apparatus which enables a user to set a region-of-interest (ROI) for higher fidelity or lower loss compression than other areas of the image. The invention incorporates a new feature for ROI coding without compromising any capabilities of the image coding method into which the ROI coding is incorporated, such as progressive by fidelity, progressive by resolution, progressive by fidelity and resolution, and lossy/lossless capabilities. Furthermore, computational complexity increase due to the implementation of the invention is minimal. The encoder output according to the prior art is a bit stream with a sequential series of bits which is ordered to reduce the overall mean squared error. The invention is a method and apparatus which modifies the ordering of the bit stream output such that

additional emphasis is placed on the region-of-interest, than other aspects of the image. In applications such as medical imaging or virtually any other type of imaging, the region of interest may not be the pixel values having the highest-ordered coefficients in a sense of reducing the MSE. The present invention, therefore, enables a user at a transmitting end or receiving end to select an appropriate region of interest which is reconstructed possibly losslessly and with a higher fidelity than the rest of the image, regardless of the importance of the region of interest in the MSE sense.

BRIEF DESCRIPTION OF THE DRAWINGS:

For a more detailed understanding of the operation of the invention, reference should be made to the attached drawings, wherein:

Figure 1 illustrates an aspect of a spatial-orientation tree, according to the prior art;

Figure 2 is a flow chart which illustrates a brief explanation of SPIHT compression according of the prior art;

Figure 3 is a summarization flow chart which illustrates the prior art;

Figure 4 is a flow chart which explains region-of-interest image coding according to the present invention;

Figure 5 is a graph which illustrates the speed of lossless reconstruction as a function of left-bit-shifts according to the present invention;

Figure 6 illustrates the PSNR performance of the present invention;

Figure 7 illustrates a result of the invention utilizing particular reconstruction rates;

Figure 8 is a photo of a lossless reconstruction of the same photo with the same region of interest as Figure 7;

Figures 9A and 9B illustrate the rate-distortion penalty associated with a coding method according to the present invention;

Figure 10 is a block diagram which illustrates a series of blocks which are utilized to implement the invention wherein ROI selection is performed on the encoding side; and

Figure 11 is a block diagram which illustrates elements utilized to implement the invention wherein ROI selection is performed on-line.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

The present invention is directed to a method and apparatus of performing still image compression wherein either a user at the transmitting side can specify what is, in his or her opinion, a region-of-interest before the encoding process, or wherein a user on the receiving side can determine the region of interest based upon the incoming bit stream and identify the desired area to place more emphasis on the region of interest during the remainder of the encoding process. In the first situation, wherein a user on the transmitting side is determining the ROI, encoding can be performed off-line. When a user on the receiving side is identifying the ROI, encoding must be performed on-line.

When the ROI is identified, only wavelet transform (WT) coefficients corresponding to the data in the ROI are scaled up by the compression method or algorithm. The compression method can be, for example, the SPIHT method of Said and Pearlman; for the purposes of this description, the SPIHT method will be referred to as an example, but this invention is not to be interpreted as being limited to SPIHT applications. The scaling up discussed previously is performed by the selected coefficients being given higher priority through a fixed number of left bit shifts, with each left bit shift corresponding to a scaling up or increase in bit significance by a factor of two in each subband. The larger number of left shifts, the higher the emphasis will be on the WT coefficients, and the more noticeable will be the speed increase of the ROI reconstruction. The encoder or decoder according to the invention, therefore, can select the region of interest, and dictate the speed with which the region of interest is reconstructed, or the amount of additional emphasis the region of interest receives with respect to the rest of the image. Referring to the invention as illustrated in Figure 4, using an SPIHT type of compression method, a sorting pass is a process beginning with an initial value or threshold of $n = N$. The method requires $N + 1$ passes to encode the

entire image up to the highest fidelity (losslessly when the wavelet decomposition is carried out through integer transform). After completing P passes (P = 0, 1, ..., N) of the encoding method, and transmitting the resulting output, the encoder or decoder identifies the region of interest and the appropriate WT coefficients are left shifted by S bits. It should be noted that P = 0 corresponds to the case where the region of interest is determined by the encoder. Large values of S, therefore, result in a speedy lossless reconstruction of the region of interest. Lower values of S result in a less significant speed increase with respect to the reconstruction of the region of interest, but result in a better reconstruction of the remainder of the image, or provide a better overall rate-distortion performance. By controlling the value of S, therefore, the user can control the level of importance of the region of interest relative to the remainder of the image.

Figure 4 illustrates the ROI coding of the present invention in a compression method such as SPIHT. Either before or during encoding, ROI selection occurs at 400. After ROI selection, the ROI coefficients are scaled up at 401, for a given threshold level. Sorting passes and refinement passes are performed on the ROI image data at 402 and 403, respectively. At 404, it is determined whether or not the number of passes are complete based upon the given threshold levels. If the number of passes are not complete, further sorting and refinement occurs. If the number of passes is complete, then it is determined at 405 whether the ROI data has been completely reconstructed. If not, appropriate sorting and refinement occurs for subsequent ROI image data. If the ROI is complete, then sorting and refinement passes are performed on the remainder of the image data at 406. Sorting and refinement is based upon a maximum threshold level N, a threshold level k where ROI coding begins, and the left bit shift value S.

In other words, assuming that P passes are completed, the region of interest is selected along with a value of S, and the selected ROI and S value are fed back to the encoder. In situations where P = 0, the encoder selects the ROI and S, and encoding can be performed off line or on-line. All WT

coefficients relating to the region of interest (ROI coefficients) are then identified, and left shifted by S bits. The current significance threshold n is increased from the current value (N - P) to (N - P + S). Encoding is then resumed on ROI coefficients, and continued for S passes until the significance threshold n = N - P. Encoding is continued on all WT coefficients until threshold n < 0. It should be noted that the actual shape or outline of the region of interest is arbitrary, as long as the overall region of interest can be described or defined as a plurality of adjacent rectangles or as a non-adjacent collection of pluralities of adjacent rectangles. The region of interest can be a single region of interest, or there can be a plurality of regions of interests which can be handled in the same manner discussed herein.

In other words, once a region-of-interest is selected, WT coefficients associated with reconstruction of the region of interest are identified in the wavelet transform domain, and only these WT coefficients are encoded/decoded according to a compression method which becomes modified to concentrate on encoding/decoding of the specified coefficients. Corresponding coefficients, therefore, are encoded/decoded at an earlier threshold cycle or earlier path than the highest priority coefficients according to the compression method such as the SPIHT. ROI coefficients are identified through tracing back of the inverse wavelet transform from the image domain to the WT coefficient domain. Inverse wavelet transformation converts image representation in the WT coefficient domain into image data in the image domain. One pixel in the image is reconstructed with a couple of WT coefficients through inverse wavelet transformation. Therefore, once the region-of-interest is specified in the image domain, WT coefficients pertaining thereto, noted as ROI coefficients, are identified by tracing back the inverse wavelet transform from the image domain to the WT domain.

The left-shifting discussed above refers to scaling the WT coefficients by a left bit shift, which corresponds to scaling by 2, 4, 8, etc., in accordance with known binary shifting. A conventional method such as the SPIHT coding algorithm handles the WT coefficients from the highest non-zero bit fields of

all coefficients (MSB), to the least significant bit (LSB). Scanning all coefficients in sequential bit depth from the MSB to the LSB as a path results in information ordering being achieved in a comparable manner. Coding the region-of-interest according to the present invention orders information by scaling up the WT coefficients pertaining to the region of interest such that they are handled or visited in an earlier path or cycle, thereby placing the ROI coefficients in an earlier portion of the encoding bit stream. The larger the left bit shift, the earlier in the bit stream the ROI coefficients are placed. Therefore, the higher the left shift value, the higher the speed of reconstruction of the region-of-interest.

When a region-of-interest is reconstructed in a lossless manner, there is no objective or subjective loss in the reconstructed region-of-interest. The amount of losslessness of the image reconstruction is based upon the wavelet transform with which the compression method generates the encoding bit stream. The encoding bit stream generates images of a wide variety of bit rates, including ones which assure losslessness of the overall image. However, if the encoding or decoding process is terminated before losslessness is assured, the reconstruction is to be considered a "lossy" reconstruction. The lower the bit rate at which the coding process is terminated, the more lossy the reconstruction result will be. Therefore, if the coding for the region of interest coefficients are terminated early, the reconstruction results of the region-of-interest would also be lossy, although with a higher level of emphasis than areas outside of the region-of-interest.

It should be noted that even when the wavelet transform is not an integer-to-integer mapping type of wavelet transform, such as a float-to-float mapping type of integer transform which is commonly called subband decomposition, QMF, etc, the region-of-interest coding according to the present invention works in the same manner as discussed above, with the exception of the fact that the reconstructed result can never be considered to be lossless, due to the fact that the wavelet transform and quantization associated therewith generates some loss which can never be recovered.

However, with this type of wavelet transform if it is assumed that the quantization result of the wavelet transform coefficients correspond to the original information in the image, then the ROI coding system of the present invention could be considered to be lossless in this configuration. However, if real losslessness cannot be achieved for non-integer wavelet transform methods, the claimed method can be considered a highest fidelity coding method instead of a lossless coding method unless integer-transform is used.

Figure 5 and 6 are graphs which illustrate performance results on a 512 x 512 image, with the region of interest illustrated by the rectangular section of Figure 7. The region of interest is a 128 x 128 square containing a portion of the image. Referring once again to Figure 5, it can be seen that the speed of lossless reconstruction of the region of interest varies as a function of the number of left shift values S. The figure illustrates results for two different values of p, those being p = 0 and p = 7. Figure 6 illustrates the peak signal-to-noise ratio (PSNR) performance of reconstruction of the entire image when the region of the interest is losslessly reconstructed, again with values of p = 0 and p = 7. For a fixed value of P, each point corresponding to a given value of S corresponds to the reconstruction PSNR and overall bit rate when the region of interest is losslessly reconstructed. Figure 7 is a photograph which illustrates the invention utilizing an SPIHT algorithm with a P = 7, which achieves a PSNR of 28.80 dB at 0.86 bpp. Figure 8 is a photo of a lossless reconstruction of the same photo with the same region of interest as Figure 7, with P = 7 and S = 7. The PSNR of this image is 29.22 dB at 0.389 bpp. When S = 5, lossless reconstruction of the region of interest can occur at 0.710 bpp, with a PSNR of 35.69 dB. When S = 0 (no region of interest defined), the lossless reconstruction of the entire image is achieved at 4.378 bpp, which is approximately one order of magnitude slower than with S = 7. The figures illustrate, therefore, that a region of interest coding technique according to the present invention provides an effective and flexible system for embedded ROI image encoding, with flexibility from varying levels of lossy coding all the way up to lossless ROI image coding. Lossless

reconstruction of the region of interest and an effective or "subjectively lossless" reconstruction of the remainder of the image can be achieved at a bit rate of 3-4 times smaller what is needed for lossless reconstruction of the overall image.

Figures 9(a) and 9(b) illustrate the rate-distortion penalty which is associated with a coding method and apparatus according to the present invention. These figures are graphs of the PSNR of the entire image in dB versus overall bit rate performance in bpp, for cases corresponding to P = 7 and S = 2, and P = 7 and S = 5. The solid lines indicate the performance of the conventional SPIHT algorithm, and the modified algorithms corresponding to S = 2 and S = 5 are indicated by the "+" and "O". It can be seen that up to a bit rate of 0.086 bpp, all three encoding schemes are identical. With a bit rate of higher than 0.086 bpp, the scheme with the larger S exhibits a larger rate-distortion loss compared to the conventional SPIHT method, but achieves a faster lossless reconstruction of the region of interest. The S = 2 scheme closely corresponds to the SPIHT result.

The methods discussed above include numerous embodiments for image compression wherein the selection of the region of interest can either be performed before encoding in an off-line situation, or during encoding in an on-line manner. When the region-of-interest is selected in the middle of transmission (on-line), the selection can be performed on the receiving side wherein the receiving side sends information to the encoding or transmitting side regarding the region-of-interest, and sorting and prioritization is adjusted accordingly. The on-line selection can also be performed by the encoding side, if the encoding side includes a local decoder which simulates a decoding process before transmission or storage of the data. The invention can be embodied in a computer system comprising a display, a central processing unit, memory, and appropriate communication means such as a modem and a telephone line, which are configured to provide an input means for inputting digital image data, such that the display means can display the digital image data. The computer system can be configured to function such that a

selecting device or selecting means is connected to the display for selecting the region of interest. A sorting and prioritizing means or device can be connected to the selecting device for sorting and prioritizing the digital image data according to at least two priority categories, with digital image data corresponding to the region of interest having a higher priority than the digital image data which corresponds to areas outside of the region of interest. The communication circuitry or device can function as a transmitting device for transmitting the sorted and prioritized data to a remote location, with the transmitting device transmitting the digital image data corresponding to the region of interest with a higher priority than the areas outside of the region of interest. The transmitted data is received by a receiving computer which would include a receiving means or device for receiving the transmitted data, and a reconstructing device for reconstructing the transmitted data. The reconstructing device would include a decoding device for decoding the sorted and prioritized digital image data. The region of interest is reconstructed by the reconstructing device at a faster rate than the digital image data corresponding to areas outside of the region of interest. In the alternative, the region of interest can be reconstructed with a higher fidelity than areas outside of the region of interest.

The threshold or path where region of interest coding begins can be determined at the beginning of the sorting pass on and overall image or in the middle of the sorting pass, as well as in the beginning or middle of a refinement pass, or in the beginning of the entire coding process. If it is determined in the beginning of the entire coding process, this can be done in an off-line manner. ROI selection done in the beginning of a sorting or refining pass is an interactive or on-line selection. In other words, for situations where n is equal to the ROI coding level, scaling up of the ROI coefficients occurs, and sorting passes and refinement passes are performed for $n = k + s$; $n > k$; $n--$.

An alternative embodiment of a system according to the present invention would be one wherein the selection of the region of interest is

performed based upon a partial reconstructed image which is received by the receiver after transmission from the transmitting means has begun. Based upon the partial reconstructed image, a user on the receiving end can select a region of interest, and the receiver then transmits data to the transmitting computer which identifies the selected region of interest. The transmitting computer then modifies the sorting of the digital image data based upon the selected region of interest. The digital image data corresponding to the region of interest is sorted and prioritized to have a higher priority than digital image data corresponding to areas outside of the region of interest. The modified sorted and prioritized data is then transmitted to the receiver, and the region of interest is transmitted with a higher priority than areas outside of the region of interest. The specific configuration of the computer elements to create means for performing the function specified above is within the purview of a person of skill in the art based upon the information contained in the specification.

Figure 10 is a block diagram which illustrates a series of elements which implement the invention wherein ROI selection is performed on the encoding side. Input means or input device 110 is used for inputting digital image data into a computer or data handling apparatus. A display means or device 111 displays the digital image data. Selecting device 112 is connected to the display device, and is used to select a region of an image represented by the digital image data. Sorting and prioritizing device 113 is connected to selecting device 112, and sorts and prioritizes the digital image data according to at least two priority categories. The selected region of interest data is given a higher priority than digital image data corresponding to areas outside of the region of interest. Transmitting device 114 transmits the sorted and prioritized data to a remote location, with the remote location being a mass storage device, a network such as an internet or intranet, wide area network, local area network, etc. The transmitted data is received by receiving device 115, wherein the transmitted digital image data is reconstructed by reconstructing means 116 having decoding means 117,

wherein the region of interest is reconstructed at a faster rate and/or with a higher fidelity than digital image data corresponding to areas outside of the region of interest.

Figure 11 is a block diagram which illustrates region of interest selection in an on-line manner. Input means or input device 121 inputs digital image data to a computer or other image data handling apparatus. The digital image can then optionally be displayed on display means 122, or, alternatively, may be communicated directly to sorting means or sorting device 123. The sorting device sorts the digital image data according to a mathematical sorting protocol, with the digital image data being sorted and prioritized according to a predetermined prioritization formula. Transmitting means or transmitting device 124 transmits the sorted data, and the sorting means repeats a sorting of the digital image data and the transmitting means repeats a transmission of the data. The data is received on a receiving device 125, which has display device 126 connected thereupon. The display device displays the transmitted data as a partial reconstructed image during the transmission. As the sorting device and transmitting device repeat their sorting and transmission, the reconstruction of the image progresses. A region of interest selecting means 127 is connected to receiving means 125, for selecting a region of interest based upon the partial reconstructed image. After selection of the region of interest, a region of interest transmitting device or means 128 transmits data corresponding to the selected region of interest to the sorting device 123. The sorting device modifies the sorting of the digital image data based upon the data corresponding to the selected region of interest. The digital image data corresponding to the selected region of interest is sorted and prioritized by the sorting device to have a higher priority than digital image data corresponding to areas outside of the selected region of interest.

The present invention takes the form of a computer program embodied on a computer readable medium, with the computer readable medium including floppy disks, mass storage devices such as hard drives, DRAM, CD-

ROM, etc. The computer program controls a general purpose computer to perform the method steps noted above.

The invention is discussed above as being implemented on a transmitting computer or device and the data is sent to a receiver or a decoding device. The invention can include configurations wherein the encoding is performed on a computer, wherein encoded image data is transmitted onto the internet for internet browsing, and decoding occurs at another computer retrieving information from the internet. The encoder and the decoder can also be disposed on a local area network (LAN) or wide area network (WAN), intranet, or can occur between a computer and a mass storage device. Applications could therefore include virtually any applications where image data transfer or storage is necessary, including telemedicine and general image archival and retrieval. The region of interest coding method and apparatus according to the invention solves bottleneck problems which occur in these applications.

The above description of the invention is for illustrative purposes only. It should be understood that the selection and reconstruction of a region of interest according to the present invention can be utilized with other types of compression methods, and that the various means which are disclosed above have numerous equivalents which would be within the scope of knowledge of a person of skill in the art. The metes and bounds of the invention are defined in the appended claims.

CLAIMS:

1. A method of image compression, said method comprising the steps of:

providing digital image data in a computer-readable format, said digital image data including data on values and coordinates for a plurality of pixels;

selecting a region of interest of an image represented by said digital image data;

sorting and prioritizing said digital image data according to at least two priority categories, with digital image data corresponding to the region of interest having a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting said sorted and prioritized digital image data to a remote location, with the digital information data corresponding to the region of interest being transmitted with higher priority than the areas outside of the region of interest.

2. A method according to claim 1, comprising the further step of:

reconstructing the transmitted digital image data at the remote location, said step of reconstructing comprising the step of decoding the sorted and prioritized digital image data, wherein the region of interest is reconstructed at a faster rate than digital image data corresponding to areas outside of the region of interest, said faster rate being provided by said sorting and prioritizing of said digital image data corresponding to the region of interest.

3. A method according to claim 1, comprising the further step of

reconstructing the transmitted digital image data, said step of reconstructing comprising the steps of

decoding the sorted and prioritized digital image data, wherein the region of interest is reconstructed at a higher fidelity and lower loss than the areas outside of the region of interest, said higher fidelity and lower loss being provided by said sorting and prioritizing of said digital image data corresponding to the region of interest.

4. A method according to claim 1, wherein said sorting and prioritizing of said digital image data comprises shifting bits of transform coefficients corresponding to the digital image data by a predetermined amount, said predetermined amount corresponding to a desired scale-up rate for reconstruction of the region of interest.

5. A method for encoding and decoding an image, said method comprising the steps of:

providing digital image data in a computer-readable format, said digital image data including data on values and coordinates for a plurality of pixels;

sorting said digital image data according to a mathematical sorting protocol, said digital image data being sorted and prioritized according to a predetermined prioritization formula;

transmitting said sorted data to a receiver, and repeating said sorting and transmitting until a partial reconstructed image appears on a display at the receiver;

selecting a region of interest based upon said partial reconstructed image;

transmitting data from said receiver to a computer transmitting data identifying the selected region of interest;

modifying the sorting of the digital image data based upon the selected region of interest, wherein digital image data corresponding to the region of interest is sorted and prioritized to have a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting said modified sorted and prioritized data to the receiver, with said region of interest being transmitted with higher priority than the areas outside of the region of interest.

6. A system for compressing a digital image, said system comprising:

input means for inputting digital image data in computer-readable format with the digital image data including data on values and coordinates for a plurality of pixels for an image;

display means connected to said input means for displaying the digital image data;

selecting means connected to said display means for selecting a region of interest of an image represented by said digital image data;

sorting and prioritizing means connected to said selecting means for sorting and prioritizing said digital image data according to at least two priority categories, with digital image data corresponding to the region of interest having a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting means for transmitting said sorted and prioritized data to a remote location, with said transmitting means transmitting the digital image data corresponding to the region of interest with higher priority than the areas outside of the region of interest.

7. A system as recited in claim 6, further comprising:

receiving means for receiving the transmitted digital image data;

reconstructing means connected to said receiving means for reconstructing the transmitted digital image data, said reconstructing means including decoding means for decoding the sorted and prioritized digital image data;

wherein the region of interest is reconstructed by said reconstructing means at a faster rate than digital image data corresponding to areas outside of the region of interest, with the faster rate being provided by the decoding means decoding the digital image data corresponding to the region of interest in a prioritized manner.

8. A system according to claim 6, said system further comprising:

reconstructing means connected to said receiving means for reconstructing the transmitted digital image data, said reconstructing means including decoding means for decoding the sorted and prioritized digital image data;

wherein the region of interest is reconstructed by said reconstructing means at a higher fidelity than digital image data corresponding to areas

outside of the region of interest, with the higher fidelity being provided by the decoding means decoding the digital image data corresponding to the region of interest in a prioritized manner.

9. A system for encoding and decoding an image, said system comprising:

input means for inputting digital image data in computer-readable format with the digital image data including data on values and coordinates for a plurality of pixels for an image;

sorting means for sorting said digital image data according to a mathematical sorting protocol, said digital image data being sorted and prioritized by said sorting means according to a predetermined prioritization formula;

transmitting means connected to said sorting means for transmitting said sorted data, wherein said sorting means repeats a sorting of said digital image data and said transmitting means repeats the transmission of said data;

receiving means for receiving said transmitted data from said transmitting means, wherein said transmitted data, said receiving means including a display means thereupon, said display means displaying said transmitted data as a partial reconstructed image during said transmission;

selecting means connected to said receiving means for selecting a region of interest of said partial reconstructed image;

region-of-interest transmitting means for transmitting data corresponding to said selected region-of-interest to said sorting means,

wherein said sorting means modifies the sorting of the digital image data based upon the data corresponding to the selected region of interest, wherein digital image data corresponding to the selected region of interest is sorted and prioritized by said sorting means to have a higher priority than digital image data corresponding to areas outside of the selected region of interest, and wherein said transmitting means transmits said modified sorted and prioritized data to the receiving means, with said selected region of

interest being transmitted with a higher priority than areas outside of the region of interest.

10. A computer program embodied on a computer readable medium, said computer program controlling a general purpose computer to perform the steps of:

displaying digital image data on a display, said digital image data including data on values and coordinates for a plurality of pixels;

permitting a user to select a region of interest on an image represented on said display by said digital image data;

sorting and prioritizing said digital image data according to at least two priority categories, with digital image data corresponding to the selected region of interest having a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting said sorted and prioritized digital image data to a remote location, with the region of interest being transmitted with higher priority than the areas outside of the region of interest.

11. A computer program embodied on a computer readable medium as recited in claim 10, said computer program controlling a computer at the remote location to perform the step of reconstructing the transmitted digital image data at the remote location, the step of reconstructing comprising the step of decoding the sorted and prioritized digital image data, wherein the region of interest is constructed at a faster rate than digital image data corresponding to areas outside of the region of interest, said faster rate being provided by said prioritizing of said region of interest.

12. A computer program embodied on a computer readable medium as recited in claim 10, said computer program controlling a computer at the remote location to perform the step of reconstructing the transmitted digital image data at the remote location, the step of reconstructing comprising the step of decoding the sorted and prioritized digital image data, wherein the region of interest is constructed at a higher fidelity than digital image data

corresponding to areas outside of the region of interest, said higher fidelity being provided by said prioritizing of said region of interest.

13. A computer program embodied on a computer readable medium, said computer program controlling a general purpose computer to perform the steps of:

displaying digital image data on a display, said digital image data including data on values and coordinates for a plurality of pixels;

sorting said digital image data according to a mathematical sorting protocol, said digital image data being sorted and prioritized according to a predetermined prioritization formula;

transmitting said sorted data to a receiver, and repeating said sorting and transmitting until a partial reconstructed image appears on a display at the receiver;

selecting a region of interest based upon said partial reconstructed image;

transmitting data from said receiver to a computer transmitting data identifying the selected region of interest;

modifying the sorting of the digital image data based upon the selected region of interest, whereby digital image data corresponding to the region of interest is sorted and prioritized to have a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting said modified sorted and prioritized data to the receiver, with said region of interest being transmitted with higher priority than the areas outside of the region of interest.

14. A method of image compression, said method comprising the steps of:

providing digital image data in a computer-readable format, said digital image data including data on values and coordinates for a plurality of pixels;

sorting and prioritizing said digital image data according to a mathematical sorting protocol, said digital image data being sorted and prioritized according to a predetermined prioritization formula;

transmitting said sorted data to a receiver, and repeating said sorting and transmitting as the image data is transmitted to the receiver;

selecting a region of interest of said digital image data;

modifying the sorting of the digital image data based upon the selected region of interest, wherein digital image data corresponding to the region of interest is sorted and prioritized to have a higher priority than digital image data corresponding to areas outside of the region of interest; and

transmitting said modified and sorted prioritized data to the receiver, with said region of interest being transmitted with higher priority than the areas outside of the region of interest.

15. A method of image compression as recited in claim 1, wherein said step of transmitting said sorted and prioritized digital image data to the remote location includes transmitting the sorted and prioritized digital image data onto an internet, wherein said remote location is a location on the internet, wherein said method further comprises the step of

reconstructing the transmitted digital image data at the remote location, said step of reconstructing comprising the step of decoding the sorted and prioritized digital image data, wherein the region of interest is reconstructed at a faster rate than digital image data corresponding to areas outside of the region of interest, said faster rate being provided by said sorting and prioritizing of said digital image data corresponding to the region of interest.

16. A method of image compression as recited in claim 1, wherein said step of transmitting said sorted and prioritized digital image data to the remote location includes transmitting the sorted and prioritized digital image data onto an internet, wherein said remote location is a location on the internet, wherein said method further comprises the step of

reconstructing the transmitted digital image data at the remote location, said step of reconstructing comprising the step of decoding the sorted and prioritized digital image data, wherein the region of interest is reconstructed at a higher fidelity than digital image data corresponding to areas outside of

the region of interest, said higher fidelity being provided by said sorting and prioritizing of said digital image data corresponding to the region of interest.

17. A method for encoding and decoding an image as recited in claim 5, wherein said step of transmitting said sorted data includes transmitting said sorted data onto a network, wherein said receiver is a receiving computer on said network, and wherein said step of selecting the region of interest is performed at said receiving computer.

18. A method for encoding and decoding an image as recited in claim 17, wherein said network is an internet network.

19. A system for compressing a digital image as recited in claim 6, wherein said transmitting means transmits said sorted and prioritized data onto a network, wherein the remote location is a receiving computer on the network, and

wherein the receiving computer includes reconstructing means therein for reconstructing the transmitted digital image data, and wherein the region of interest is reconstructed by the reconstructing means at one of a faster rate and a higher fidelity than digital image data corresponding to areas outside of the region of interest, with the one of the faster rate and the higher fidelity being provided by the decoding means decoding the digital image data corresponding to the region of interest in a prioritized manner.

20. A system for encoding and decoding an image as recited in claim 9, wherein said transmitting means transmits said sorted data onto a network, and wherein the receiving means is a receiving computer on said network.

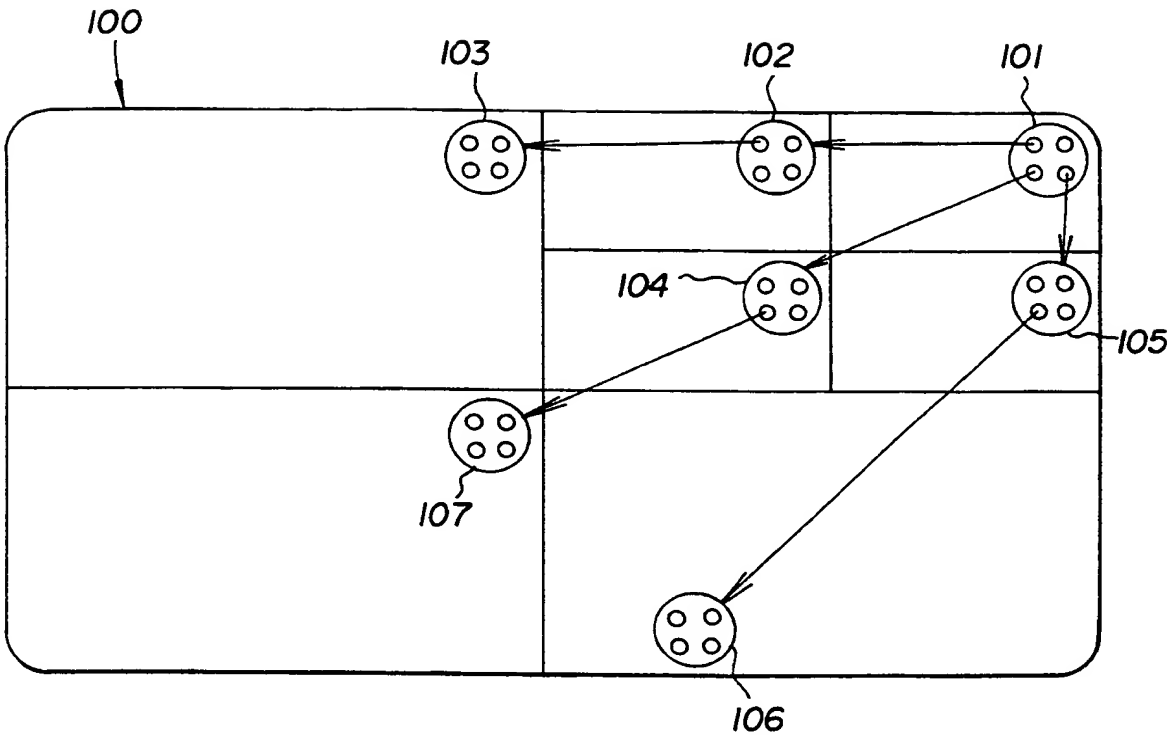
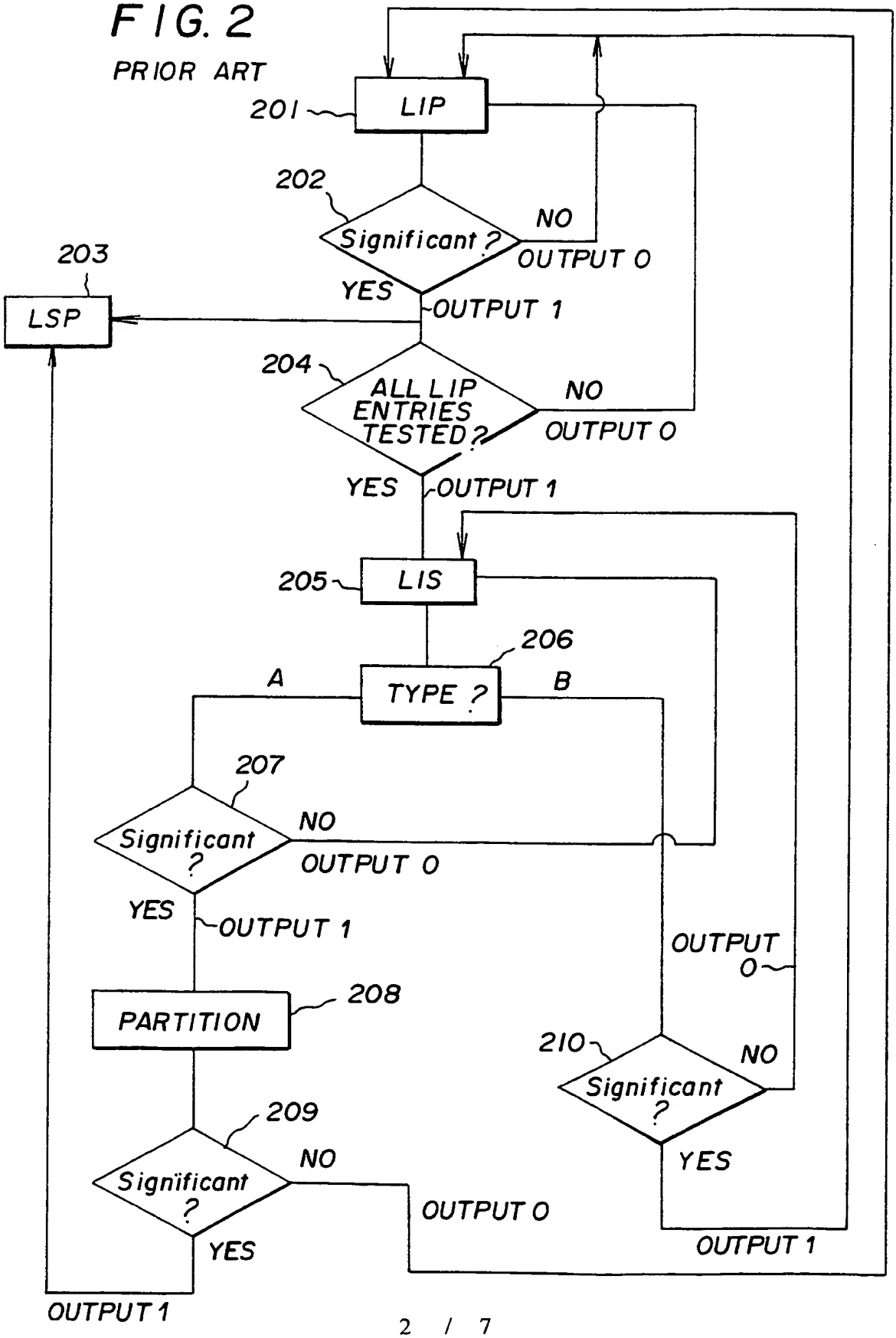


FIG. 1

PRIOR ART

FIG. 2
PRIOR ART



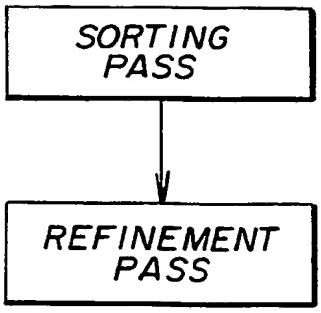


FIG. 3
PRIOR ART

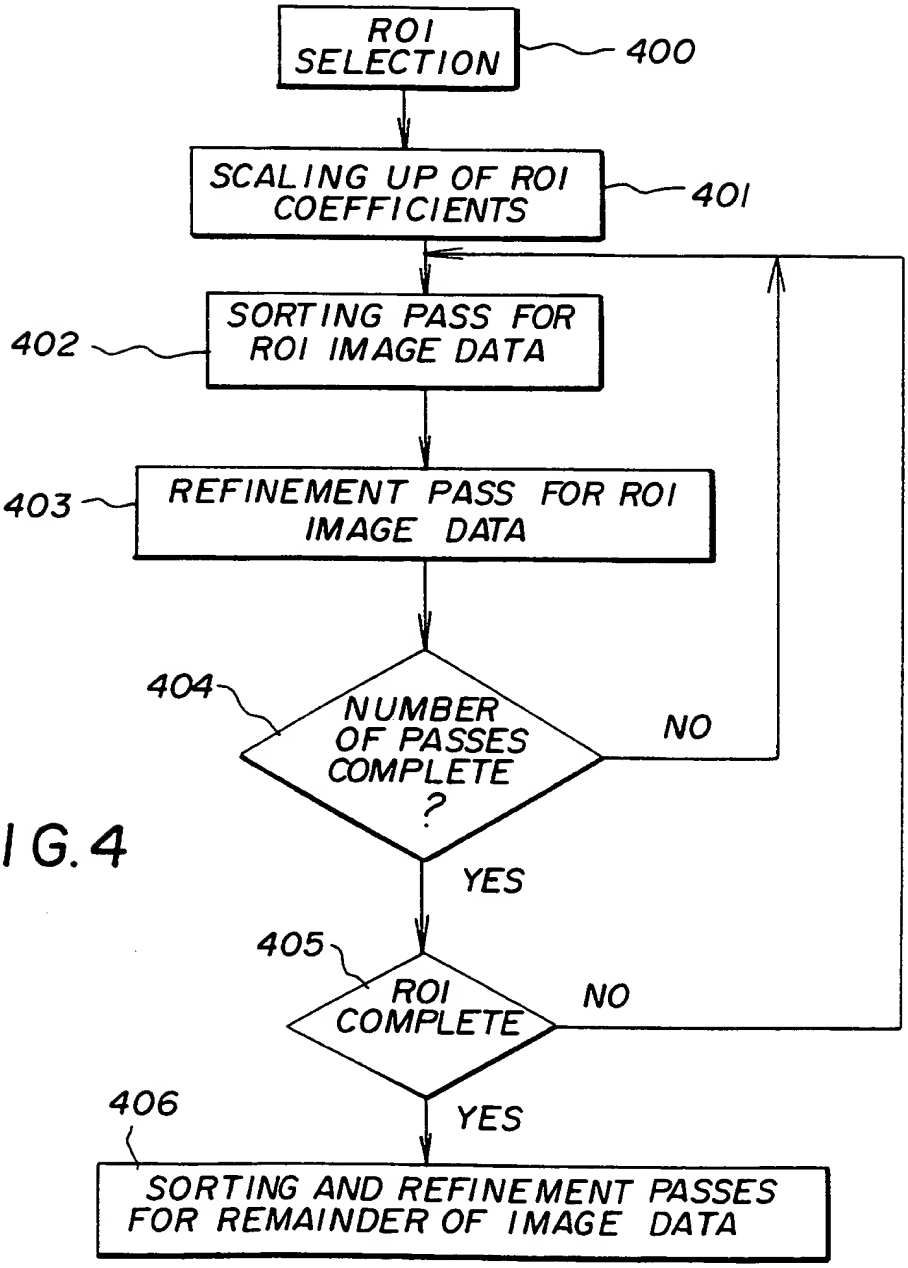


FIG. 4

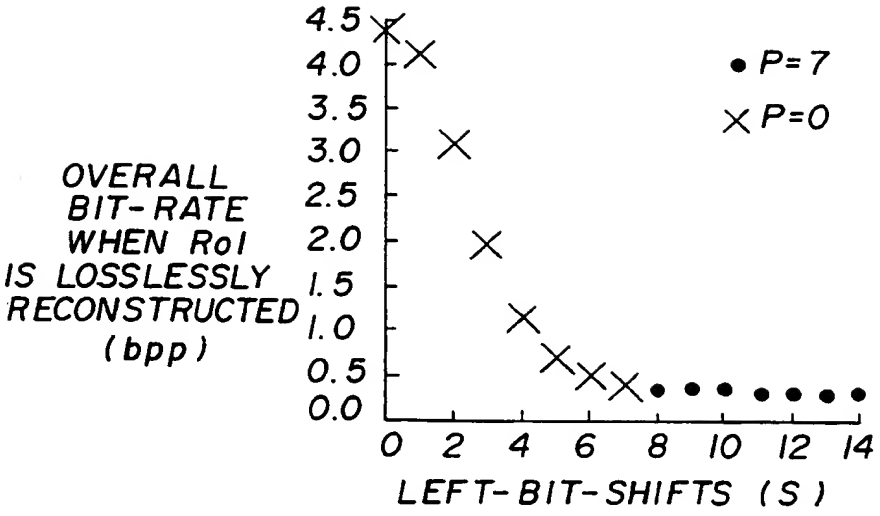

OVERALL BIT-RATE WHEN RoI IS LOSSLESSLY RECONSTRUCTED (bpp)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0 2 4 6 8 10 12 14
LEFT-BIT-SHIFTS (S)
P=7
P=0

FIG. 5

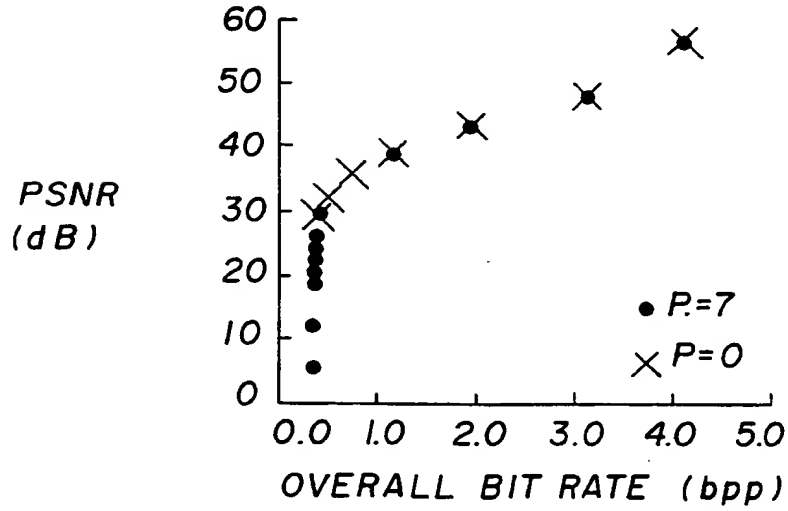

PSNR (dB)
60
50
40
30
20
10
0
0.0 1.0 2.0 3.0 4.0 5.0
OVERALL BIT RATE (bpp)
P=7
P=0

FIG. 6

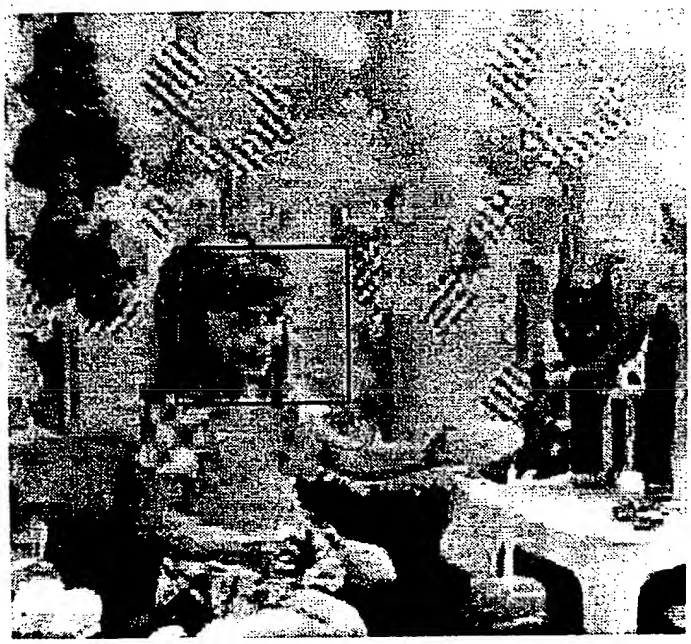


FIG. 7

FIG. 8

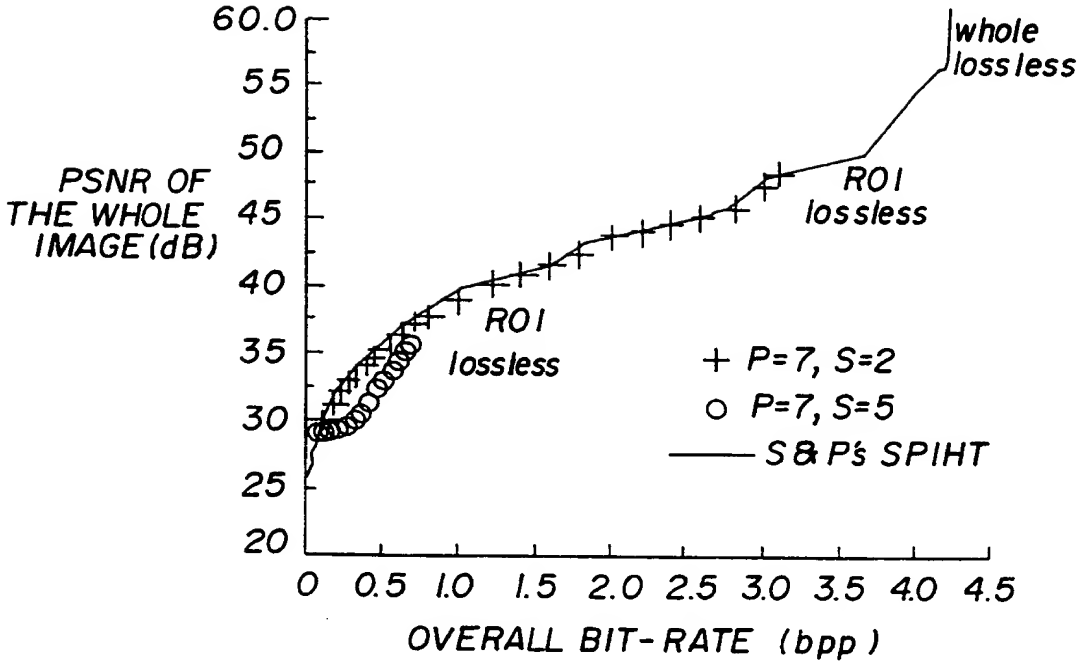

60.0
55
50
45
40
35
30
25
20
PSNR OF THE WHOLE IMAGE (dB)
whole lossless
ROI lossless
ROI lossless
+ P=7, S=2
○ P=7, S=5
S & P's SPIHT
0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
OVERALL BIT-RATE (bpp)

FIG. 9(a)

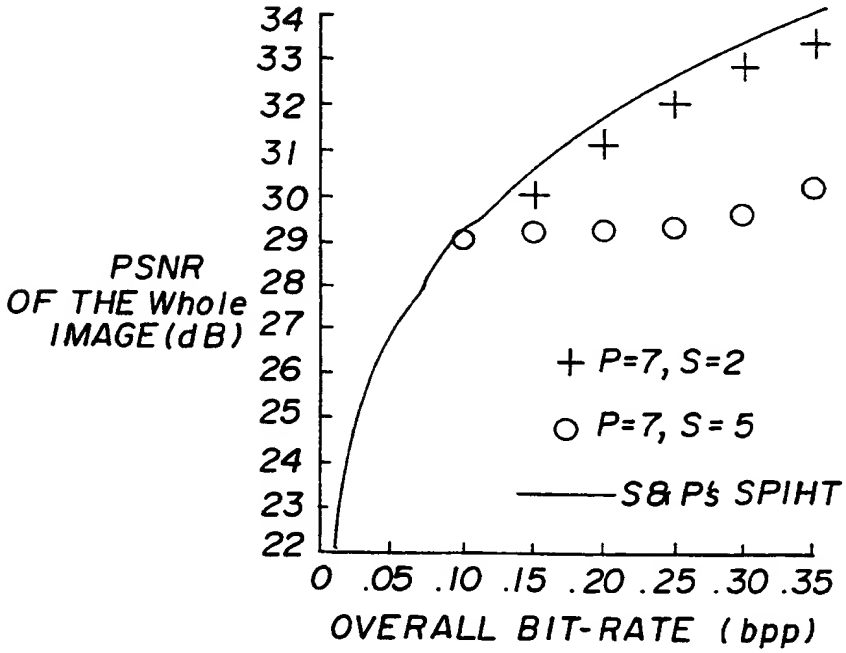

34
33
32
31
30
29
28
27
26
25
24
23
22
PSNR OF THE Whole IMAGE (dB)
+ P=7, S=2
○ P=7, S=5
S & P's SPIHT
0 .05 .10 .15 .20 .25 .30 .35
OVERALL BIT-RATE (bpp)

FIG. 9(b)

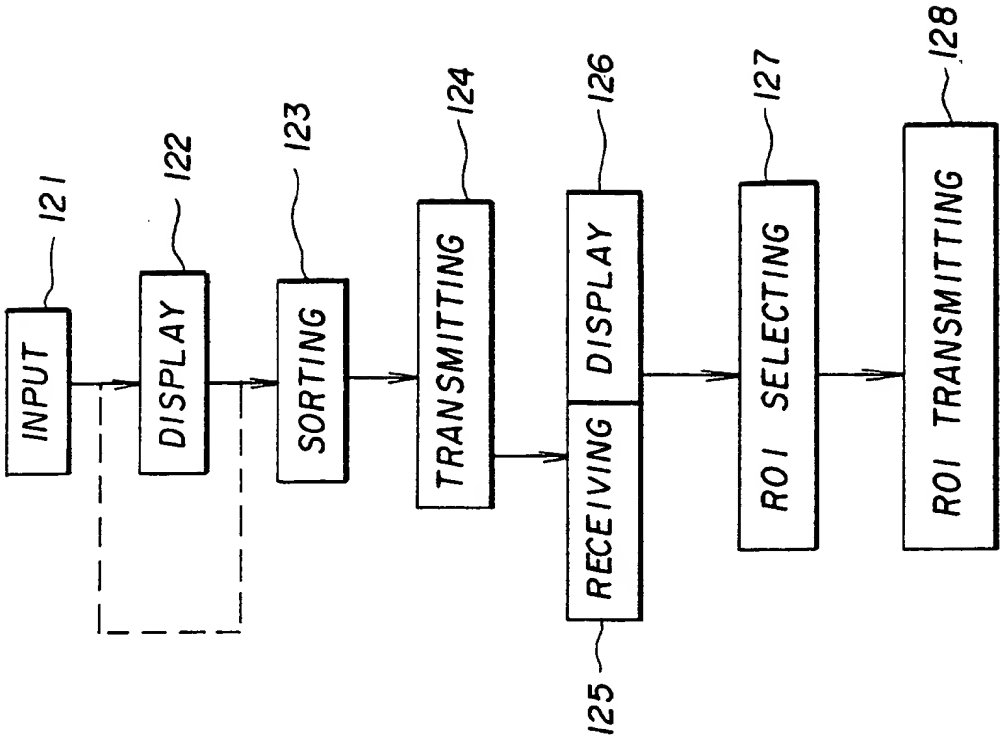

INPUT
121
DISPLAY
122
SORTING
123
TRANSMITTING
124
RECEIVING
DISPLAY
125
126
ROI SELECTING
127
ROI TRANSMITTING
128

FIG. 11

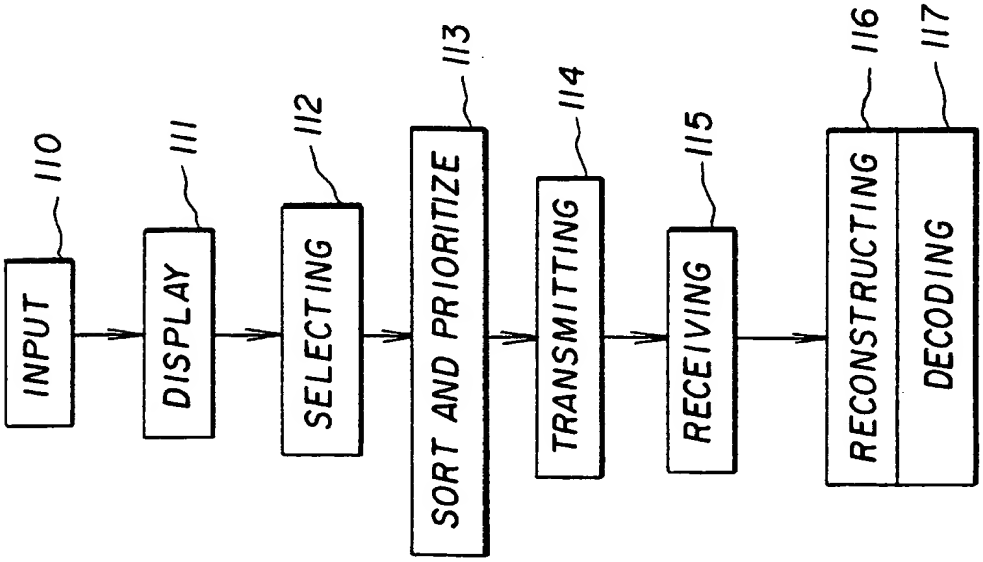

INPUT
110
DISPLAY
111
SELECTING
112
SORT AND PRIORITIZE
113
TRANSMITTING
114
RECEIVING
115
RECONSTRUCTING
DECODING
116
117

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03811

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06K 9/36
US CL :382/240

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/232,233,234,235,239,240,244,248; 348/397,398,400,408,423,426,430,437,438

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,412,741 A (SHAPIRO) 02 MAY 1995, column 3, line 40 through column 15, line 47 and figures 1-10.	1-20
A	US 5,563,960 A (SHAPIRO) 08 OCTOBER 1996, see figures 1-11 and refer to column 3, line 25 through column 15, line 15.	1-20
A	US 5,586,200 A (DEVANEY ET AL.) 17 DECEMBER 1996, see figures 1-27 and refer to column 4, line 31 through column 34, line 41.	1-20
A,E	US 5,748,876 A (HARDY) 05 MAY 1998, see figures 1-4 and refer to column 2, line 60 through column 6, line 16.	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
03 JUNE 1998

Date of mailing of the international search report
12 AUG 1998

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